Renewable Energy Research and Development: A Political Economy Perspective

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Introduction

There are many benefits associated with shifting from an energy system based primarily on fossil fuels to one based on renewable energy and energy efficiency (REEE) and other low-carbon sources. In addition to the reduction in greenhouse gases, countries and subnational regions can benefit from reduced air pollution, from a more secure energy supply, and from economic development if the new energy sources displace imported energy.

Because the benefits are clear, one might expect that an energy transition would occur quickly, but progress at all levels of governance—from cities, provinces, states, and countries to global arrangements—has been slow. Technical factors have impeded the transition, among them the high cost of solar energy; the problem of transmission for wind resources, which are often located far from population centers; the intermittency of solar and wind energy and the expense of energy storage; and the problem of integrating distributed energy into electricity grids that are based on stable baseload power and centralized distribution. But there are also political-economic factors that impede a more rapid energy transition. In many cases corporations associated with the existing energy regime—fossil-fuel producers, utilities, and companies in industries that are heavily reliant on fossil-fuels—view energy-transition policies as a threat to their profitability and existing models of business. In some cases

the incumbent actors have mobilized in the political field to block policies in support of REEE and decarbonization, and their political opposition has included reduction of support for scientific research on climate change and REEE.

A political economy perspective can allow the robust interpretation and explanation of the emergence of opposition to energy transition policies. In this chapter we will describe our approach to the political economy of science and technology, then discuss how it works using data drawn from changes in state-government policies with respect to REEE in the United States.

Conceptual Background

The term "energy transition" will be used here to refer to changes in energy technologies that lead to a reduction in greenhouse gas emissions. Although there are various types of greenhouse-gas emissions, the focus here will be on carbon-dioxide and an energy transition primarily understood as decarbonization. The outcome of an energy transition entails a fundamental change across various industries, including electricity, transportation, agriculture, buildings, and manufacturing. The focus in this study will be on the electricity industry. There are various terms in use to describe an alternative to an electricity system that is heavily reliant on fossil fuels, which in most countries means a combination of coal and natural gas. REEE is a narrow category represented primarily by hydropower, solar, wind, and geothermal energy and by energy-efficiency technologies. In turn, REEE is one type of low-carbon energy, which can include nuclear energy and fossil fuels when configured with carbon sequestration and with energy-efficient technologies such as combined heat-and-power. The focus here will be on greater reliance on REEE rather than on the full range of low-carbon energy technologies.

Some industrial transitions take place largely through marketplace processes, but in the case of a heavily regulated industry such as electricity government policy is especially important. Government policy sets the conditions for a transition by providing funds for research, incentives for the

development of new technologies, and regulatory support for them to scale up. Because of the importance of government policy, the industrial transition can be a highly political process. Coalitions of industrial incumbents can emerge to slow or block transition policies, and likewise transition coalitions can emerge to support those policies.

A political economy approach provides one important framework for understanding the politics of energy transitions. We understand "political economy" broadly as the study of how political and economic institutions and actors influence each other. Two of the most central points of reference in an adequate political economy framework are social structure and institutional structure. Social structure refers to the enduring relations of inequality categorized by class, race, ethnicity, gender, sexuality, global position, and other aspects of social structure (Hess et al. 2016b). In the case of low-carbon energy transitions, lack of support for environmental policy is often linked to the capacity of sectors of the dominant class to oppose stronger environmental regulations. However, energy-transition politics can also involve conflicts within the dominant class. For example, there have been some instances of support for energy transition policies by the technology and investment industries in the U.S. (Hess 2016a).

The second main point of reference in a political economy approach involves institutions, or the enduring areas of social action that have their own roles, rules, values, and cognitive categories. (Powell and DiMaggio 1991). Examples of social institutions that are relevant to this project are government, industry, science, and civil society. Institutions are nested and interacting; for example, government regulation occurs at multiple scales, from cities to global treaty frameworks. Interactions across institutions occur through a variety of mechanisms, such as when actors bring their different forms of capital—for example, the social capital of networks or their financial capital—to bear on their strategies within different fields. We draw on field theory as a framework for analyzing action and strategies within and across institutions (Bourdieu 2001, Fligstein and McAdam 2012). This approach emphasizes

how actors accumulate and spend various types of capital and how they acquire and change a system of meanings that inform their dispositions for action.

To understand how scientific and technological change occurs in institutions and fields, we also draw on transition studies, a body of research that has its roots in work on large technical (or technological) systems (LTSs). An LTS is a heterogeneous ensemble of natural resources, a sociotechnical system (organizations, laws, practices, infrastructure, products, consumers), and a cultural system of cognitive and normative categories. An LTS is generally associated with an industrial system such as transportation, electricity, and food production, and LTSs undergo changes or transitions from one configuration to another. The case of electricity as an LTS was historically important in science and technology studies because of Hughes's work (1983, 1987) on the transition of urban lighting systems and buildings from gaslight to electricity. We are interested in the transition of the electricity system from a configuration based on the use of fossil fuels for stable electricity generation (or "baseload power") from centralized power plants to a configuration that includes a much larger role for distributed generation (such as rooftop solar that is connected to the grid), energy storage and "smart grid" technologies, and the use of renewable energy and other low-carbon energy sources.

Whereas Hughes developed a phase model of the transition of LTSs, subsequent work on industrial transitions has emphasized conflict among actors. This work has tended to focus on institutional structure and to emphasize relations of conflict and cooperation between incumbents and challengers in an industrial field. Although social structural factors such as class and gender can be included, they tend to be addressed via a residual category known as the "landscape" (Geels 2011). The incumbents are associated with a configuration of the LTS known as a regime, whereas challengers often begin as relatively minor actors located in niches of the LTS. The actors who support the development and scaling up of niches can be scientists and entrepreneurs with funding from venture capital or government agencies, or they can be part of the research-and-development efforts of large

corporations. Niches can be symbiotic with the industrial regime, in which case their innovations can be incorporated into the regime with little conflict, or they can generate deep institutional conflict (Geels and Schot 2007). These conflicts can take the form of large, established organizations versus smaller start-ups (e.g., the electricity utilities versus the solar installation firms). However, in the case of electricity there are also conflicts between utilities and firms in countervailing industries, such as finance, that support the scaling-up of the niches, such as rooftop solar.

In our case, the incumbents include both the utilities, which favor a stable system of centralized power, and fossil-fuel production firms, which provide a particular form of centralized, baseload power. An energy transition away from reliance on centralized, baseload power toward distributed REEE threatens the utilities because it could lead to the growth of off-grid electricity generation (Kind 2013). For example, households and businesses could build on-site energy storage for their solar power and effectively disconnect from the grid. Because of this potential for REEE to be deeply disrputive, the utilities prefer to slow the transition and, as the innovations develop, to steer them toward the dominant configuration, such as by building centralized solar farms instead of enabling the development of rooftop solar. The coal industry is also threatened because electricity is the main source of demand for coal, and an energy transition could mean the bankruptcy of firms. For the natural gas industry, there could be a sharp decline in demand as the market becomes restricted to the heating of buildings rather than including the use of natural gas to power large electricity generation facilities.

When incumbents form a political alliance to block a transition and to support the existing regime, they engage in “regime resistance.” In transition studies, this topic is not yet well developed, but there is increasing interest in it (Geels 2014; Hess 2016a, 2016b). Regime resistance can focus on specific policies that the incumbents attempt to block, but it can also involve more general alliances with other industrial groups. In the U.S. these regime coalitions have constructed an institutional field of public relations firms, lobbyists, think tanks, campaign spending organizations, and organizations that create a

"corral" around the government (Barley 2010). Supported by large corporations and by wealthy donors, of whom some of the most prominent have ties to the fossil-fuel industry, this institutional field has shifted political discourse toward conservative (neoliberal) and anti-regulatory policy preferences. Regime resistance can include this general, long-term historical development, but for our purposes the focus will be more on the specific, short-term dimensions of regime resistance associated with opposition to specific REEE policies.

Although the economic resources of regime actors tend can make conflicts between incumbents and challengers over industrial transitions a David-and-Goliath struggle, the challengers associated with transition coalitions have various options that they can use to overcome regime resistance. Among the options are the mobilization of countervailing industrial power and ideological judo. For example, wealthy donors in California associated with the finance and technology sectors provided significant funds to support the state's global warming law against a ballot initiative that was sponsored by out-of-state fossil-fuel firms and that would have rolled back the law. Similar countervailing industrial power can be found in other political conflicts over energy transitions in state governments in the U.S. (Hess 2014). Ideological judo refers to the translation of pro-transition policies into policy instruments that are consistent with conservative values (Hess 2016b). REEE policies that are configured to reduce government regulation, such as "red tape" that makes it hard to gain solar photovoltaic permitting, tend to gain higher levels of support than renewable portfolio standards, which require utilities to produce a specified percentage of REEE by a given date, such as 25% by 2025 (Hess et al. 2016a, Hess 2016a).

The analysis that follows will explore the political and economic factors that impede a more rapid energy transition on a global level, then it will use a comparative analysis of U.S. state government policy to examine how regime resistance occurs through the alliance of political conservatives with pro-fossil fuel regime actors. The case of electricity transition politics in the U.S. provides a good basis for

developing general knowledge about regime resistance, the politics of transitions, and the political economy of science and technology.

Energy Transitions in Global Perspective

During the 2008 U.S. presidential elections, both Republican and Democratic presidential candidates acknowledged the existence of global warming and the need to have a policy to mitigate greenhouse gas emissions. However, after the Republican Party gained control of the U.S. House of Representatives in 2011, opportunities to pass legislation to mitigate greenhouse gas emissions ended in the federal government. Republicans in Congress frequently expressed climate denialism and began a campaign to reduce funding to science research that addressed climate change and energy transition issues. They proposed and sometimes achieved cutbacks in climate-related and REEE research in a wide range of government agencies (Morello et al. 2011, U.S. House of Representative 2011). By attacking not only energy-transition policy but scientific research programs, conservative political leaders linked the issue of energy-transition policies to the scientific field and to the politics of research funding. In turn, this strategy created a situation of undone science, or the systematic underproduction of research due to lack of support from political and industrial elites (Hess 2016b).

Although the U.S. is arguably the world leader in climate denialism and opposition to REEE research and development, similar opposition has appeared from conservative governments in Australia, Canada, and the U.K. (Carter and Clements 2015, Young and Coutinho 2013). For example, Canadian Prime Minister Stephen Harper withdrew from the Kyoto Protocol and ended the government's National Round Table on the Environment and the Economy, which reports on climate-related issues. The government also censored its own scientists and cut funding for climate-related research (Ogden 2015). In Australia Prime Minister Tony Abbot's government repealed the country's carbon tax, ordered the government's Clean Energy Fund to stop investments in wind and small-scale

solar energy, proposed cuts of 69% to the Australian Climate Change Science Program, and eliminated some environmentally related agencies (Dayton 2014). In the U.K. the conservative government increasingly turned against REEE development (Carter and Clements 2015). Although climate change denialism is particularly influential in the neoliberal, Anglophone countries, it has also spread to other areas of the world (Dunlap and McCright 2015, Tranter and Booth 2015).

Even in countries where there is relatively strong support for energy-transition policies from parties across the political spectrum, there can be significant differences of views on what the ideal pace of the transition should be and on what its effects and side effects have been. For example, in Germany support for the feed-in tariff for solar energy came mainly from the Green Party and Social Democratic Party, whereas opposition came from the more conservative Christian Democratic Party and Liberal Democratic Party (Hoppman et al. 2014). Although the conservative parties supported renewable energy under the Energiewende policy, they also sought to weaken the feed-in tariff law and the growth of solar energy. The changes came in response to concerns raised by the utilities about the growth of distributed solar energy, which was being produced by independent organizations and was undermining utility profitability, and with general concerns about the cost of electricity and economic competitiveness.

There is little information on political conflict and green-energy transition policies in other countries. Our comparative analysis of 18 Asian countries found that countries with relatively low levels of policy support for renewable energy were poorer, more authoritarian, and more heavily endowed with fossil fuels (Hess and Mai 2014). The study also found that some of the countries have high reliance on hydropower and are likely to reduce the percentage of renewable energy as they grow their electricity system to meet increased demand. Because some of the countries are adding generation capacity by increasing the level of fossil-fuel production, they are actually engaged in an energy transition toward fossil fuels. In general, in the smaller and poorer developing countries, the primary

focus is still on electrification and on meeting demand growth, and the severe budgetary constraints of these countries have tended to make REEE a luxury that they perceive as unaffordable.

From a greenhouse-gas emissions perspective, policy reform in the large industrializing countries is important because of their growing contribution to emissions. Although the goals set in the Conference of Parties 21 in Paris in 2015 do not represent binding commitments, leading industrialized countries did agree to intended Nationally Determined Contributions (iNDCs). For example, Brazil set the goal of reducing economy-wide greenhouse gas emissions by 43% by 2030 from 2005 levels; China announced that it will achieve peak greenhouse gas emissions by 2030 and will reduce its carbon intensity by 60-65% below 2005 levels; India announced the similar goal of reducing its carbon intensity by 30% below 2005 levels by 2030; and Mexico announced that it will reduce its emissions by 22% by 2030 relative to business as usual and will reduce black carbon (soot) by 51% (United Nations 2015). Although such proposals are a welcome development, they will likely be far from adequate for the goal of reducing global emissions at a pace required to prevent the worst risks predicted by climate scientists. In many developing countries, growth in emissions has to date outpaced decarbonization efforts, and goals are still framed in terms of energy intensity rather than the reduction of total emissions. Even so, we do not see the same level of organized resistance to REEE policies from the fossil-fuel sector that is evident in some of the industrialized Anglophone countries. It is possible that the high projected growth of energy production in industrializing countries reduces the potential threat to the existing regime, and it is also possible that the transition to solar and wind energy is not as advanced as it is in some of the wealthier, industrialized countries. If these are the correct explanatory factors for the relative lack of opposition in the industrializing economies, then opposition may emerge when demand growth slows and the non-hydro REEE portion of the energy mix increases. We would especially expect opposition if renewable energy growth is not owned and controlled by the regime actors, such as the utilities.

REEE Policy in the American States

As the country with the highest level of opposition from industrial incumbent organizations to decarbonization policies, the U.S. provides a good laboratory for a detailed examination of the political economy of REEE. The specific focus here will be on the issue of regime resistance that has emerged in the political field as part of the alliance among the utilities, donors associated with the fossil-fuel industries, and conservative political leaders. We focus on state governments because much of REEE policy in the U.S. is developed and implemented at that level. The analysis that follows is based on the assumption that one avenue for examining the political economy of REEE is through the effects of party changes on policy. In many cases, political party conflicts in the U.S. have become closely aligned with support for fossil fuels (higher in the Republican Party) versus support for decarbonization policies (higher in the Democratic Party). The campaign finance system facilitates the influence of utilities and fossil-fuel companies by allowing firms and wealthy donors to affect campaigns through donations and independent spending. The 2010 U.S. Supreme Court decision of Citizens United v. the Federal Election Commission opened the floodgates for political spending in what was already an important pathway of influence between the industrial and political fields.

In the 2010 mid-term elections, the conservative wing of the Republican Party defeated moderates in the primary elections, and support of moderate Republicans for energy-transition policies was a divisive issue in some campaigns. In addition to the shift within the Republican Party that purged moderates, the party also gained control of the U.S. House of Representatives and several governors' offices and state legislative bodies that had been controlled by Democrats. In other words, the 2010 election was largely regarded as a rout for the Democrats, but it also represented a shift within the Republican Party toward hardened opposition to REEE policies. Increasingly the elected officials of the Republican Party in both the federal and state governments opposed REEE legislation, many also voiced

climate denialism, and in some state legislatures Republicans attempted to repeal renewable energy portfolio standards, including laws that had passed with bipartisan votes only a few years earlier. Likewise, whereas Republican governors prior to 2008 had in some cases supported a cap-and-trade approach to carbon regulation and other policies favorable to a "green economy," they increasingly opposed such proposals and supported the development of fossil fuels such as natural-gas fracturing technologies. Although some Republican leaders maintained support for REEE policies, they became a minority within the party. Candidates for office in the Republican Party became acutely aware of the risks that such support could entail to reelection campaigns, where spending from the network of pro-fossil-fuel donors could support primary challenges from candidates whose views were stridently opposed to climate science and REEE.

In the section that follows we examine the effects of the changes of political party on REEE policy, with a focus on policies that support research, economic development, or industrial growth for the REEE sector. We selected states that had a change of the party of the governor between 2010 and 2015. We did not include Florida, where Governor Crist began as a Republican but switched parties to become an independent. We began with a baseline analysis of state government policies in support of REEE conducted with a team of students in 2010 (Hess et al. 2010). This analysis identified a range of REEE policies, including programs that supported REEE research and development. McKane then analyzed state-government web sites and news reports to examine to what extent the programs were still in effect. This provided a beginning inventory of shifts in REEE policy directly related to research and development. Additional searches of news reports for the governor and REEE policy were conducted to identify other examples of how the shift from Democratic to Republican governors was associated with important changes in REEE policy.

The result is an inventory of the most significant examples of REEE policy shifts associated with changes in the political party of the governor during the specified period. Often Republican Party control

of the governor's office coincided with control of both houses of the legislature by the Republican Party, but our focus is on the governors. In most cases Republican governors opposed the Environmental Protection Agency's proposed Clean Power Plan, which proposed to regulate carbon-dioxide emissions from electricity power plants. Because opposition to the Clean Power Plan was widespread, we do not include it in the analysis. We grouped the presentation of policy changes by the four U.S. Census Bureau regions. (See Table 1.)

Region	State	Date	Outgoing Democrat	Incoming Republican	Legislative Composition, Governor's First Year
Midwest	Illinois	2015	Quinn	Rauner	Both Democrat
	Iowa	2011	Culver	Bransted	Split (House R., Senate D.)
	Kansas	2011	Parkinson	Brownback	Both Republican
	Michigan	2011	Granholm	Snyder	Both Republican
	Ohio	2011	Strickland	Kasich	Both Republican
	Wisconsin	2011	Doyle	Walker	Both Republican
Northeast	Maine	2011	Baldacci	LePage	Both Republican
	Massachusetts	2015	Patrick	Baker	Both Democratic
	New Jersey	2010	Corzine	Christie	Both Democratic
	Pennsylvania	2011	Rendell	Corbett	Both Republican
South	Arkansas	2015	Beebe	Hutchinson	Both Republican
	Maryland	2015	O'Malley	Hogan	Both Democratic
	N. Carolina	2013	Perdue	McCrory	Both Republican
	Oklahoma	2011	Henry	Fallin	Both Republican
	Tennessee	2011	Bredesen	Haslam	Both Republican
West	New Mexico	2011	Richardson	Martinez	Both Democratic
	Wyoming	2011	Freudenthal	Mead	Both Republican

Table 1. Shift from Democratic to Republican Governor, 2010-2015

Region	State	Policy Changes under Republican Governor
Midwest	Illinois	• Budget for 2016 proposes cuts to REEE programs (legislature rejected): end to Energy Efficiency Portfolio Standard Fund and Renewable Energy Resources Trust Fund
	Iowa	• Governor signs S.F. 2340, 2014: triples solar tax credits • Governor signs S.F. 2343, 2014: extends wind tax credits • Governor supports ethanol and national renewable fuels standard • Governor does not defend Iowa Energy Center when utility threatens to withhold funding
	Kansas	• Governor signs HB 2101, 2014: reduces payments to net metering customers • Governor signs SB 91, 2015: changes state's renewable portfolio standard from mandatory to voluntary
	Michigan	• Centers for Energy Excellence, established under previous Democratic governor, does not approve additional REEE projects • Advanced vehicle battery manufacturer credit ended • Alternative fuel and vehicle research, development, and manufacturing credit ended • Governor opposes 2012 ballot initiative for a 25% renewable portfolio standard (initiative failed)
	Ohio	• Governor signs S.B. 310, 2014: freezes Ohio's RPS for 2 years, creates Energy Mandates Study Committee to evaluate effectives of the RPS • Governor opposes indefinite freeze of RPS • Ohio Third Frontier (business development program) shifts from fuel cells and advanced energy to start-up programs
	Wisconsin	• Governor ends Green to Gold Fund (energy–efficiency improvements) • Governor opposes implementation of Wind Siting Rules (PSC 128), which leads to withdrawal of wind-energy projects • Governor's 2015 budget cuts $8 million for bioenergy research
Northeast	Maine	• Governor vetoes LB 1252, 2014: tax to support solar energy (legislative override) • Governor vetoes LB 1263, 2015: to create a stakeholder group to develop an alternative to net metering (legislative override)
	Massachu-setts	• Governor appoints former fossil-fuel lobbyist to lead energy policy • Governor signs S1979, 2016: raises net metering cap but lowers payment to 60% of retail rate • Governor supports natural gas and hydropower development
	New Jersey	• Governor withdraws state from Regional Greenhouse Gas Initiative • Governor's 2011 Energy Master Plan has cutbacks for REEE and support for natural gas development • Governor signs SB 2036, 2010: in support of offshore wind, but his Regulatory Committee creates hurdles for wind development
	Pennsylvania	• Governor supports natural gas resource development • Governor dismantles programs that support REEE (Green Government

		Council and Office of Energy Management) • Alternative Energy Development Program of Ben Franklin Technology Partners unfunded as of 2015
South	Arkansas	• No changes identified
	Maryland	• Governor blocks regulations to reduce coal plants' nitrogen-oxide emissions because of concerns he had with the effects on costs • Governor downsizes Maryland Energy Administration • Governor opposes raising utility rates to expand energy-efficiency efforts • Governor signs SB 323, 2016: to reduce greenhouse gas emissions by 40% from 2006 levels by 2030 • Governor vetoes HB 1106, 2016: bill to increase RPS
	N. Carolina	• 2013 state government budget cuts funding completely for Biofuels Center • The Department of Energy and Natural Resources removes information on climate change from its web site and reassigns officials who worked on climate change
	Oklahoma	• Governor supports climate denialism • Governor signs SB 1456, 2014: authorizes monthly charge for electricity customers with solar panels
	Tennessee	• Governor signs HB 62, 2013: increases taxes on solar and wind facilities • Governor reduces solar investment policies of Democratic predecessor • Governor supports HB 1268, 2013: supports energy-efficiency for state government buildings
West	New Mexico	• Governor fires Environment Improvement Board • Governor appoints climate-change denier to run Energy, Minerals, and Natural Resources Department • Governor prevents publication of a rule to require a 3% reduction in greenhouse-gas emissions • Governor ends Energy Innovation Fund for solar and biofuels • Governor vetoes HB296 (2015): to extend solar tax credits • Governor vetoes funding for Renewable Energy Transmission Authority in 2015
	Wyoming	• In 2013 governor unveils energy policy focused on development of fossil fuels

Table 2: Summary of Major REEE Policy Shifts in States with a Change to Republican Governor, 2010-2015

Key: HB= house bill, RPS=renewable portfolio standard, REEE=renewable energy and energy efficiency, SB=senate bill

The summary of the REEE policy changes associated with a change from a Democratic to a Republican governor indicates that in many cases there were attempts to roll-back REEE policies. (See Table 2.) An exception was Governor Bransted of Iowa, but Iowa has well-developed wind and biofuels industries that are supported by powerful rural constituencies, and these forms of REEE tend to have bipartisan support. Furthermore, the governor had served a previous term and had supported REEE policies, and he was not part of the wave of anti-environmental "Tea Party" Republicans. The state also had a split legislature, a condition that means that bipartisan efforts are required in order to approve legislation.

In states with Democrat-controlled legislatures, there is no consistent pattern of gubernatorial policy. Massachusetts is a very Democratic state with a history of strong support for REEE policy under Democratic Governor Patrick, and Republicans in the state tend to be more moderate than in other regions of the country. Consistent with this moderate position, Governor Baker supported a compromise solar law, but the law had a crucial feature of ending net metering policy (payment for rooftop solar generation at the retail rate), which the utilities have been seeking in many states. He also indicated the need to expand energy sources by including more natural gas and hydropower, but he signaled willingness to expand hydropower if there was no or weak political support for natural gas. In other states with shifts to Republican governors and Democrat-controlled legislatures (Illinois, Maryland, New Jersey, and New Mexico), the governors generally attempted to dial back the strong support that energy transition advocates had enjoyed under previous Democratic governors.

There is also a pattern in the types of REEE policies that were targeted. First, there was no new development of renewable portfolio standards or regional carbon trading regimes under the newly elected Republican governors. Our interviews with state-government legislators and their aides indicated that Republicans view these policies as unwanted government mandates (Hess et al. 2016a). In Kansas, the renewable portfolio standard was changed to voluntary, in Michigan the governor opposed

a ballot initiative that would have supported a constitutional change in favor of REEE, in Ohio the governor supported a temporary freeze on the standard, and in New Jersey the governor withdrew from the regional greenhouse-gas cap-and-trade agreement. In contrast, there are several cases where the newly elected Republican governors explicitly supported more natural gas development while they blocked supportive programs for wind energy and for solar. In the case of solar, the utilities were engaged in a comprehensive campaign to weaken net metering laws and other support for distributive solar energy, and Republican governors often supported these policy changes. Republican governors also downsized government agencies associated with REEE and cancelled funds in support of REEE research and development.

Discussion

The sharp differences between Republicans and Democrats on energy-transition policies in the U.S. are symptomatic of the broader polarization on issues in American politics (McCright et al. 2014, Shor and McCarty 2011). The causes of the polarization trend are complex, but there is arguably a connection with political economy in the sense of the concentration of wealth, the weakening of labor unions, and other dimensions of class conflict. The mobilization of wealthy conservations and large corporations to build the institutional field to influence government described above has led to an increasing rightward drift of the Republican Party and a drift in the political center to the right. In the case of environmental policy, one dimension of this institutional field, political spending by interest groups, clearly favors the fossil-fuel sector. For example, whereas donations from the alternative energy sector favor Democrats slightly, the much higher level of donations from the oil and gas, coal, and utility industries strongly favored Republicans (Center for Responsive Politics 2015). Sociologists have also documented the flow of funding from conservative donors, of whom some prominent donors have connections with the fossil-fuel sector and conservative foundations (Brulle 2014). Furthermore, the

American Legislative Exchange Council (2015), a conservative organization that supports the dismantling of REEE policies, has claimed support from more than one-fourth of all state legislators.

A political economy perspective based on class power and industrial influence provides a good explanatory framework for the general pattern of polarization that is evident in energy policy in the U.S. The perspective can also help to explain variation in the degree of support from Republicans for energy transition policies, such as the cases in which Republican governors have been relatively supportive of energy transition policies. In addition to the case of Iowa discussed above, a similar pattern of support for REEE policy occurred in California and New York, where former Republican Governors Schwarzenegger and Pataki were relatively supportive of REEE policy. The mobilization of regime resistance by industrial incumbents is likely to be particularly effective if the economy associated with the state government has strong fossil-fuel resources and/or fossil-fuel employment. Conversely, as the REEE sector grows and catalyzes a strong political constituency (e.g., farmers in Iowa or the clean technology sector in California), this constituency will tend to over-ride the regime resistance of the fossil-fuel sector and utilities. At the other extreme is Wyoming, a conservative state with a high level of fossil-fuel employment. Neither the Democratic nor the Republican governor showed much support for wind energy, even though the state has significant wind-energy resources and the capacity to export the energy to other states. Thus, there are variations in the mobilizing capacity of the industrial incumbents that affect the political opportunities for advocates of deepened energy-transition policies. Various studies indicate that the endowment of fossil-fuel resources is a predictor of policy support for REEE among state governments (e.g., Coley and Hess 2012, Vasseur 2014), and this factor also can explain some variation across countries (Hess and Mai 2014).

An additional perspective based on institutional and field theory can also bring out some complexities in the relationship between the Republican Party and support or opposition for REEE. Research that our group conducted on Republican-controlled legislatures indicates that there are some

types of REEE policy that still garnered bipartisan support during this period (Hess et al. 2015, 2016a). Specifically, if the policies use instruments that are consistent with conservative values, they can gain support from conservative legislators. One example is support for building efficiency standards for government (not private-sector) buildings, a policy that can reduce government spending and inefficiency. An example from Table 2 is Tennessee's HB 2013, which supports energy-efficiency measures in government buildings. In some cases Republican-controlled legislatures also provided support for solar and wind tax credits, a measure that benefits the private sector and also is consistent with conservative views that support tax reduction. However, in New Mexico the Republican governor vetoed a bill that would have extended solar tax credits, and in Tennessee the state government approved a law to increase solar and wind taxes. Thus, a solar tax credit is not a guarantee of bipartisan support, but it is one pathway to gaining support in some cases. Republican-controlled legislatures also supported legislation in support of property-assessed clean energy, or PACE, which allows businesses and homeowners to obtain financing for REEE improvements with support of funds from local bond initiatives. Although there are sometimes pockets of opposition to PACE laws, in general the laws are seen as market-enabling and therefore consistent with conservative philosophies of government (Hess et al. 2016a).

This approach is consistent with STS research on the politics of design, which draws attention to the political meanings of different types of design configurations of LTSs (Winner 1986, Hess 2016b). Applied to REEE politics, policy instruments that use mandates are the most likely to clash with conservative values and tend to be the ones that conservatives will try to roll-back. Republican governors have also cut funding for programs that support REEE research-and-development, a policy move that is consistent with conservative opposition to government subsidies and to the problem of "picking winners and losers" that is associated with industrial policy. In contrast, more market-enabling policy instruments, such as tax credits and PACE laws, are less controversial.

Conclusion

There is great value in an approach to the political economy of science and technology that begins with structural inequality associated with class conflict and corporate power. We have indicated the importance of such classical political economy factors at play in the energy transition politics of the U.S. Wealthy donors and powerful corporations have formed an immensely influential political mobilization that has supported a fossil-fuel regime as an important element of the broader neoliberalization of the political field. However, the political field has some degree of autonomy, and a classical political economy perspective anchored in social structure can be made more effective when used with insights from institutional and field theory. The interests of elites are translated and redefined as they are expressed in the political field, where distinctions among types of policies are important. These distinctions in turn depend on the systems of meaning that orient action in the field, specifically the clash between conservative and progressive ideologies. The partial autonomy of the political field from influence by powerful industrial firms and donors makes it possible for some forms of support for REEE to continue even in the context of roll-backs and mounting opposition. Thus, it is still possible to find some kinds of support for REEE policies from conservatives in a polarized political environment. The goal of regime resistance is refracted by the institutional logics of the political field, and differences among policy instruments can create opportunities for some bipartisan agreement.

The conflict between challengers and incumbents in an industrial field is primarily an institutional rather than social structural conflict. The challengers include coalitions of environmentalists, some labor unions, consumer groups, and other actors associated with social movements, but they also include entrepreneurs, venture capitalists, technology firms, and other segments of industry, some of which include representatives of powerful countervailing industrial firms. The case of energy transition policy conflicts therefore has broader implications for the study of the

political economy of science and technology. We have shown that there is considerable value for a perspective on the political economy of science and technology that brings together conflicts of institutional and social structure by drawing on insights from institutional, field, and transition studies.

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